



Guidance Document for the Establishment of Critical Aquifer Recharge Area Ordinances

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Guidance Document for the Establishment of Critical Aquifer Recharge Area Ordinances

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1.0 Background and Purpose of Document

In 1990, the Washington State Legislature adopted the Growth Management Act, Engrossed Substitute House Bill 2929, now codified as Chapter 36.70A RCW (Revised Code of Washington). This statute combined with that of Article 11 of the Washington State Constitution mandates that local jurisdictions adopt ordinances that classify, designate, and regulate land use in order to protect critical areas. Critical areas are defined as wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas, and those areas necessary for fish and wildlife conservation. This guidance document focuses upon the establishment of Critical Aquifer Recharge Area (CARA) ordinances necessary to protect ground water quality and ensure that sufficient aquifer recharge occurs to maintain the quantities necessary to support ground water's use as a potable water source.

In order to assist local jurisdictions in meeting the requirements of the Growth Management Act as it pertains to CARAs, the Department of Ecology has created this guidance document which provides information on several key areas within a local ordinance. This document attempts to address the following questions:

- a) How can a local ordinance integrate existing federal and state statutes and regulations related to ground water quality and quantity protection?
- b) What is considered a technically valid determination of a critical aquifer recharge area boundary and to what extent should additional characterization be required for a given activity once a jurisdiction makes an initial determination?
- c) What types of land-use activities should be considered prohibited, provisional, or acceptable?
- d) What mitigation measures should be employed towards an activity to allow it to continue yet afford the ground water adequate protection?

2.0 Concepts Surrounding Ground Water Protection

Several concepts exist regarding ground water protection which are general in nature. They are applied regardless of whether it is a local ordinance, federal or state statute, state regulation or guidance. These facts are included below and should, to the greatest extent possible, be incorporated into local ordinances as baseline statements or underlying concepts:

- a. All ground water is vulnerable to contamination; however, hydrogeologic conditions in some areas create a greater potential to convey contamination from points of recharge (locations where ground water is replenished) to the point of use. To protect ground water in these sensitive areas, it is necessary to first determine where such areas exist using technically sound but realistic methodologies.

- b. A CARA delineation is best based upon the known or suspected vulnerability of aquifer(s) within a designated area. The determination of an aquifer's vulnerability is based on aquifer susceptibility combined with a contaminant's ability to enter and move within the aquifer media. The vulnerability determination is based upon known and inferred conditions developed from limited field data. In many cases it will be difficult to determine known conditions. In these situations it is necessary to adopt a conservative approach as it applies to contaminant migration. In this case it is assumed that contaminants will not be either retarded or degraded as they pass from the surface to the underlying aquifer(s). Using this approach will entail basing initial critical aquifer recharge areas on susceptibility. As additional data becomes available delineation is likely to be modified and based on a combination of aquifer susceptibility and contaminant behavior.
- c. Previous geologic and/or hydrogeologic characterizations contain information valuable to determining where a CARA may exist. All readily available information pertaining to designations of aquifer susceptibility or aquifer vulnerability should be used in order to complete an initial determination.
- d. Previous water quality information, collected as part of a study or survey, which indicates degraded ground water or negative changes in ground water quality, should be considered as an indication of susceptible ground water.
- e. Protection of ground water quality in CARAs shall not be done to the detriment of ground water recharge. A lack of potable ground water is as harmful to public health and safety as is ground water contamination.
- f. To the greatest extent possible, ordinances resulting from the requirements of the Growth Management Act should address the requirements of the Water Pollution Control Act, the Water Resource Act of 1971, Ground Water Quality Standards, and Washington State's antidegradation policy.

3.0 Purpose and Intent

A CARA ordinance should include a statement of purpose or intent. This statement should outline, in general terms, the goal of the ordinance. A foundation for this goal can be found in Chapter 365-190-080(2) WAC (Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands, and Critical Areas), and Chapter 173-200 WAC (Ground Water Quality Standards). Simply stated, the purpose of a CARA ordinance, is to provide a mechanism by which to classify, designate, and regulate those areas deemed necessary to provide adequate recharge and protection to aquifers used as sources of potable (drinking) water. An example of such language is presented below for consideration:

*"The Growth Management Act requires **(local jurisdiction)** to designate areas and adopt development regulations for the purpose of protecting areas within the **(city/county)***

critical to maintaining ground water recharge and quality. The Growth Management Act, Water Pollution Control Act, Water Resources Act of 1971, and the Ground Water Quality Standards require that these actions be taken to protect ground water quality and quantity such that it's use as potable water can be preserved for current and future uses.

This ordinance shall define a scientifically valid methodology by which the (local jurisdiction) will designate areas determined to be critical in maintaining both ground water quantity and quality. This ordinance shall specify regulatory requirements to be enacted when development within these areas is proposed to occur.”

The intent of this language is to clearly convey the purpose of the ordinance, which is to define and regulate CARAs. It is necessary that the ordinance be made holistic in nature by:

- 1)Addressing the specific requirements of the Growth Management Act;**
- 2)Addressing at the local level, the issue of ground water protection specified in the Water Pollution Control Act and Water Resources Act of 1971 and;**
- 3)Establishing requirements that are in conformance with Washington State’s antidegradation policy.**

3.1 Relationship of Ordinance to Existing Statutes and Regulations

Protection of ground water quality and quantity cannot be separated. Impact to one will cause impact to the other. Therefore, when local governments develop CARA ordinances, they should attempt to incorporate water quantity protection concepts from Chapter 90.44 RCW (Regulation of Public Ground Waters), with the water quality protection provisions from Chapter 90.48 RCW (Water Pollution Control Act), Chapter 90.54 RCW (the Water Resources Act of 1971), Chapter 173-200 WAC (the Ground Water Quality Standards), and Washington State's antidegradation policy.

Ground Water Quality

Ground water quality protection in Washington State is based upon the concept of antidegradation which forms the foundation for each of the state's ground water protection program(s). The Growth Management Act requirement for determination and regulation of aquifer recharge areas is in conformance with each of the statutes and regulations listed above. The antidegradation policy was originally presented in the state's overall water quality protection legislation (Chapter 90.48 RCW and Chapter 90.54 RCW). Antidegradation has been enunciated as policy in Washington State's ground water quality standards (see Chapter 173-200 WAC, Section 030). The antidegradation policy states:

Existing and future beneficial uses shall be maintained and protected, and degradation of ground water quality that would interfere with or become injurious to beneficial uses shall not be allowed.

Degradation shall not be allowed of high quality ground waters constituting an outstanding national or state resource, such as waters of national parks and wildlife refuges, and waters of exceptional recreational or ecological significance.

Whenever ground waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected, and contaminants that will reduce the existing quality thereof shall not be allowed to enter such waters, except in those instances where it can be demonstrated that:

- (i) An overriding consideration of the public interest will be served; and*
- (ii) All contaminants proposed for entry into said ground waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment prior to entry.*

The antidegradation policy combined with the state's ground water protection goals dictate that, at a minimum, all ground water should be protected as a potential source of drinking (potable) water. Not all ground water is presently used as a drinking water source. However, the potential for future use of ground water resources not currently utilized for drinking water purposes requires protection. This concept forms the basis of

Critical Aquifer Recharge Area Ordinance Development Guidance

requiring determination and protection of those areas on both a state and local governmental level.

Ground Water Quantity

Population increases within the state place larger and larger demands on the available potable water sources. The need to protect the availability of ground water is becoming more acute. This fact has been realized and is being addressed by the legislature through a series of statutes and subsequent development of administrative regulations. Among the more notable actions is the passage of the water reuse legislation (SSB 5606), the development of water reuse standards by the Department of Ecology, and the passage and implementation of the critical areas provisions of the Growth Management Act. Additionally, the numerous regulations pertaining to the establishment of in-stream flows on regulated streams also pertain to the preservation of ground water quantity (at least that necessary to maintain base flow).

4.0 Definitions

In order to establish a common understanding of terms used in a CARA ordinance, it is necessary to present definitions to be used throughout the ordinance to describe various terms and actions. The need for common terms between the ordinance language and related federal and state statute or regulation cannot be overemphasized. Appendix Three contains commonly used definitions dealing with ground water and ground water vulnerability assessment. Use of these definitions will ensure continuity between adopted ordinances and related federal and state statute and/or regulation.

5.0 Classification of Critical Aquifer Recharge Areas

The classification of a jurisdiction's CARA(s) is required under Chapter 36.70A.050 RCW. The specific methodology by which this classification is to take place has been left to the local jurisdiction. Guidance published by the Washington Department of Community, Trade and Economic Development specifies that aquifer vulnerability is to form the foundation for a determination of a CARA. Generally, there does not exist sufficient information to determine an aquifer's vulnerability. However, exceptions do exist in areas of the state, which have, in the past, been the subject of intense hydrogeologic characterizations (i.e., Clark, North Thurston, and Franklin Counties). Instead of a vulnerability determination, it is suggested that a jurisdiction attempt to determine an aquifer's susceptibility. A susceptibility determination will allow a jurisdiction to designate CARAs using a conservative approach, which provides a worst case scenario for contaminant movement in the subsurface.

5.1 Methods of Determining Susceptibility

Aquifer susceptibility studies within Washington, Oregon, and Idaho indicate that, while there are numerous factors which may be considered in determining aquifer

susceptibility, there are three that generally dominate any determination. These factors are:

- 1) The overall permeability of vadose zone material (this includes both the permeability of the soil and permeability of material underlying);
- 2) The thickness of the vadose zone (this may also be considered as the depth to water in unconfined conditions); and,
- 3) The amount of recharge available (either natural precipitation or artificial irrigation. Each of these parameters is considered critical in determining susceptibility of underlying aquifers.

Determination of Susceptibility Using Rating Systems

Rating systems which, at a minimum, rely on the factors noted above, will generally be acceptable in determining a “first cut” designation as to which areas within the jurisdiction are to be considered CARAs. The success of any rating system will depend upon its usability (for both the regulating and regulated community), availability of information, the scale to which that system is applied, the weight given to the various components of that system, and the ease with which the system may be used.

Permeability of Vadose Zone

The vadose zone is composed of both the soil and the geologic materials underlying the soil. To adequately determine the overall ease with which water will travel from the land surface to the aquifer it is necessary to determine the overall permeability of both soil and geologic media. Soil permeability can be determined through use of the county specific Soil Survey. Permeability for each soil type can be found in tables describing the physical and chemical properties of soils. Generally, these values are given in the inches per hour water moves downward through a saturated soil. The extent of the various soil permeabilities can be found in maps that accompany each Soil Survey. A determination of the permeability of geologic material underlying the soil is more problematic.

Permeability of underlying material can be estimated by conducting a review of well logs existing for the area(s) of concern¹. These logs contain a description of the geologic material (or matrix) through which a well was installed. Permeability can be estimated using Table Two in Appendix Two by determining the material type and assigning the appropriate permeability range for the material(s) overlying the uppermost aquifer. In cases where heterogeneous material are encountered, the least permeable layer with a

¹ It is recommended that a well density of at least 2-3 wells per square mile be used to determine geologic matrix and depth to water. Well logs are available from the Department of Ecology’s regional offices or in some cases local health departments.

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thickness of not less than 5 feet shall determine the overall permeability to be applied to the entire vadose zone, excluding the soil layer.

Infiltration

Infiltration or the degree to which water moves through the vadose zone into the uppermost aquifer (excluding direct injection) can be estimated using information provided in Appendix Three. Infiltration is determined by taking into account all available moisture (rainfall, snowfall, irrigation, etc.) and subtracting the moisture lost due to evapotranspiration. Approximate precipitation is obtained by locating the station nearest to the area of concern and subtracting the potential evaporation, again, from the nearest station. The determination of infiltration should always be viewed as an approximation and subject to modification as additional data is collected. ***Remember, it is important to include any artificial irrigation in the total precipitation amount. This is vital in areas where evapotranspiration exceeds precipitation (Eastern Washington).***

Depth to Water

Depth to water is the distance between the land surface and the uppermost aquifer. This distance is also defined as the vadose zone or unsaturated zone. Depth to water is estimated using well logs for wells, which have been previously drilled, within the area of concern. The density of wells for which information exists should be no less than that used to determine geologic the matrix. The use of wells logs will not provide for an exact determination of the depth to the uppermost aquifer, rather they are to be used as a basis for estimating that depth across a relatively large area one-half to one square mile.

Determination of Susceptibility Using Wellhead Protection Areas

The determination of Wellhead Protection Areas is required for all Class A water systems in the state of Washington. The determination of a wellhead protection area is based upon the time of travel of a water particle from its source to the wellbore. The time of travel is based on several factors including the permeability of the vadose and saturated zone, whether the aquifer is confined or unconfined, the pumping rate of the well, and construction of the well itself. Concurrent with the wellhead mapping, water purveyors are also required to collect site specific information to determine the susceptibility of the water source to surface sources of contamination. Water sources are ranked by the Washington State Department of Health as either a high, moderate or low susceptibility to surface contamination.

Use of wellhead protection area boundaries and accompanying susceptibility ratings can be used to refine local aquifer susceptibility within critical aquifer recharge areas, and/or differential priority areas within a larger critical aquifer recharge area. Wellhead protection areas which have been derived using either analytical or numerical modeling techniques based on acquired geologic and hydrogeologic data, will yield a technically valid local susceptibility and (in some cases) a local vulnerability. Modeling can include

defining a wellhead protection area using a calculated fixed radius, per Washington Department of Health guidance²

As wellhead protection area delineation methods are refined (either at the state or federal level), and those methods become accepted standards, modifications to previously defined classified areas are recommended.

Determination of Susceptibility Using Previous Hydrogeologic Characterizations

Numerous areas of the state have been the subject of recent characterization studies conducted as part of a regional facility siting study, remediation project, water supply study, or contaminant distribution analysis. In some cases these characterizations contain assessments of aquifer susceptibility and/or vulnerability. The results of these types of studies may be sufficient to base the boundaries of CARA provided the quality assurance is high enough. Generally, characterizations completed by the U.S. Geological Survey, the Washington State Department of Ecology, the U.S. Department of Energy, or the Washington State Department of Health are of sufficient quality on which to base a CARA. Additionally, studies, which have been conducted by virtue of a grant or loan from either the Washington State Department of Ecology or the U.S. EPA and reviewed by the agency(s), may be used. On a case by case basis, characterizations conducted by other jurisdictions that fall outside the grant or loan concern may be used to support the boundaries of a critical aquifer recharge area. These studies include those conducted to support a Ground Water Management Area under Chapter 173-100 WAC.

Determination of Susceptibility Using Soil Classifications

Soil classifications found in the county-specific Soil Survey maps published by the Natural Resources Conservation Service (previously known as the Soil Conservation Service branch of the U.S. Department of Agriculture) can provide excellent information regarding the permeability of the upper portions of the vadose zone. This information exists for each county within the state and is readily available. Use of the Soil Survey as an element in determining aquifer susceptibility is valid, especially where shallow ground water exists (0-10 feet below land surface) or where soil layers are unusually thick. In most cases however, exclusive use of the Soil Survey to determine aquifer susceptibility is not technically valid and will not meet the use requirement of "best available science".

The determination of a technically valid CARA will require the use of best available science. The methodologies and data used to make CARA determinations will vary by area. At a minimum, the data types listed previously combined with the methodology in Appendix Two should be used. If there exists additional information from, regional or local hydrogeologic studies that would refine the results obtained through use of Appendix Two, that data should be used in order to achieve "best available science".

6.0 Prohibited Activities

² Appendix E of Washington State Wellhead Protection Program Guidance Document, DOH publication #331-018, April 1995

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The purpose of the CARA provisions in the Growth Management Act is to protect ground water quality and to preserve its use as a dependable potable water source. To that end it is necessary to evaluate future land uses in order to determine what potential they may have to impact both current and future beneficial uses of the resource. It is important to note that federal and/or state statute or regulations currently regulate land uses, which have the greatest potential to impact ground water quality and recharge. The siting and operational criteria for these activities should be used by the local jurisdiction as a foundation on which to develop a listing of prohibited activities within a designated CARA. In some cases it may be necessary to impose a ban on a specific activity because it represents a high potential for contamination and low potential for remediation of the underlying aquifers used as potable water sources. The types of activities that should be considered for universal prohibition are:

Landfills: This category includes hazardous or dangerous waste, municipal solid waste, special waste, woodwaste, and inert and demolition waste landfills. Each of these activities are regulated by federal and state regulation that contain both siting and operational criteria. These criteria either prohibit these activities altogether or prohibit them in areas designated as requiring special protection. Chapter 173-304 WAC does not include a siting prohibition for inert and demolition landfills; however, the regulation does include operational criteria that restricts the type of material to be landfilled. Unless there are strict controls and an acceptable quality assurance/quality control program in place, it has generally been shown that it is impossible to control the material entering these types of facilities. In each case, if ground water contamination were to be detected under or around the facility, the cost of remediation would be exorbitant, and the time required to conduct such remediation would likely result in some degree of contamination of the potable water source.

Underground Injection Wells: Underground injection wells are regulated under Part C § 300h of the federal Safe Drinking Water Act and under Chapter 173-218 WAC. There are five classes of injection wells, two of which are authorized within the state of Washington. Class I, III, and IV wells are prohibited. Class II wells are permitted under Chapter 173-218 WAC by the Washington State Department of Ecology in conjunction with the Washington State Department of Natural Resources.

Class V wells generally do not require a permit; however, in some cases where these wells may inject industrial or commercial waste fluids that would cause a violation of Washington's ground water quality standards, a permit may be issued by the Department of Ecology or the activity will be prohibited. Because these wells may inject directly into an underground source of drinking water, the local jurisdiction should consider a prohibition against the following subclasses; 5F01, 5D03, 5F04, 5W09, 5W10, 5W11, 5W31, 5X13, 5X14, 5X15, 5W20, 5X28, and 5N24. Aquifer remediation wells are generally allowed under a State issued permit. Aquifer remediation wells at Leaking Underground Storage Tanks facilities are allowed under Department of Ecology guidance.

Mining: Metals mining has been demonstrated to be a significant threat to ground water quality. Generally, metal mining activities are confined to specific geologic areas of the state within the Northern Cascade Mountain Range, north central, and northeastern Washington. Metals mining impacts ground water quality through the physical act of extracting the ore and through use of surface impoundments for solution extraction and stormwater retention.

Sand and gravel mining poses a threat to ground water quality by raising both dissolved and suspended solids in the aquifer; and by removal of protective layers above the aquifer, creating a “window” into the aquifer through which contamination can easily move. Sand and gravel operations are required to adhere to conditions of a general water quality permit issued by the Washington Department of Ecology; however, in order for the permit to be effective in protecting the resource, the operator must adhere to all conditions. In areas deemed critical or highly susceptible, it is recommended that sand and gravel mining not take place.

Wood Treatment Facilities: Past history has indicated that wood treatment facilities can significantly impact ground water quality through uncontrolled discharge of metals and toxic synthetic compounds. The main cause of ground water contamination from wood treatment sites can be traced to poor operational practices at treatment areas and uncontrolled seepage of contaminated stormwater in areas used for drying. Ground water cleanup at several sites around the state has resulted in the expenditure of millions of dollars and has rendered previously productive drinking water sources useless. Wood treatment facilities that allow any portion of the treatment process to occur over permeable surfaces (both natural and man-made) should be prohibited.

Other: Activities that would significantly reduce the recharge to aquifers currently used or potentially used as a potable water source or as significant baseflow to a regulated stream should be considered for prohibition. These activities are defined as those that would:

- Further reduce the current infiltration available to potable ground water sources within a ground water basin of 10% or more; or:
- Cause violation of established in-stream flows.

Determining which activity may or may not be prohibited will depend on several factors and include:

- 1) *Total impermeable surface within a basin at the time a specific project is proposed. Using these criteria, there will be cases where earlier projects will be authorized but later projects may or may not require significant mediation. For*

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example: A facility proposes a parking lot of ten acres. The current area of the basin that is available for recharge, is 400 acres, of which 35 acres have previously been paved and cannot contribute to recharge. The current proposal would raise the impermeable surface area in the basin from 8.75 % to 11.25%. Therefore the proposal should be denied or modified so that infiltration galleries or infiltration ponds are constructed.

- 2) Total artificial recharge occurring within a basin. Projects that exceed the criteria above may be allowed depending on the current or future degree to which artificial recharge occurs. Artificial recharge may occur through water reclamation projects or through injection of potable water as a “water banking” project.

7.0 Conditionally Permitted Activities

Generally, activities which pose a moderate threat to the ground water quality can be allowed if sufficient mitigation measures are imposed and implemented and do not adversely affect aquifer recharge or infiltration. A determination of degree of threat should also include consideration of the susceptibility of the aquifer and potential of the activity to pollute.

When considering permitting a conditional activity, the jurisdiction should require that the proposed activities employ AKART (all known, available, and reasonable treatment) to ensure that the highest degree of protection is afforded to the aquifer(s). A local jurisdiction may reference the existing federal or state statute or regulation, which pertains to the specific activity for guidance on mitigative measures within their CARA ordinance.

In the statutes or regulations listed below, local government, through use of the critical areas provisions of the Growth Management Act and the Ground Water Quality Standards, is encouraged to impose further conditions that it deems necessary to protect sensitive or susceptible ground water areas or locations.

Table One: Statutes, Regulations, and Guidance Pertaining to Ground Water Impacting Activities

Activity	Statute - Regulation - Guidance
Above Ground Storage Tanks	Chapter 173-303 -640 WAC
Animal Feedlots	Chapter 173-216 WAC, Chapter 173-220 WAC
Automobile Washers	Chapter 173-216 WAC, Best Management Practices for Vehicle and Equipment Discharges (WDOE WQ-R-95-56)
Below Ground Storage Tanks	Chapter 173-360 WAC
Chemical Treatment Storage and Disposal Facilities	Chapter 173-303-182 WAC
Hazardous Waste Generator (<i>Boat Repair Shops, Biological Research Facility, Dry Cleaners, Furniture Stripping, Motor Vehicle Service Garages, Photographic Processing, Printing and</i>	Chapter 173-303 WAC

<i>Publishing Shops, etc.)</i>	
Injection Wells	Federal 40 CFR Parts 144 and 146, Chapter 173-218 WAC
Junk Yards and Salvage Yards	Chapter 173-304 WAC, Best Management Practices to Prevent Stormwater Pollution at Vehicles Recycler Facilities (WDOE 94-146)
Oil and Gas Drilling	Chapter 332-12-450 WAC, WAC , Chapter 173-218 WAC
On-Site Sewage Systems (Large Scale)	Chapter 173-240 WAC
On-Site Sewage Systems > 14,500 gal/day	Chapter 246-272 WAC, Local Health Ordinances
Pesticide Storage and Use	Chapter 15.54 RCW, Chapter 17.21 RCW
Sawmills	Chapter 173-303 WAC, 173-304 WAC, Best Management Practices to Prevent Stormwater Pollution at Log Yards (WDOE 95-53)
Solid Waste Handling and Recycling Facilities	Chapter 173-304 WAC
Surface Mining	Chapter 332-18-015 WAC
Waste Water Application to Land Surface	Chapter 173-216 WAC, Chapter 173-200 WAC, WDOE Land Application Guidelines, Best Management Practices for Irrigated Agriculture

The mitigative measures imposed will depend upon the size and scope of the project as well as the potential for a release to cause significant harm to public health. Mitigation measures for activities may be found in existing federal or state guidance documents. A listing of the more utilized guidance documents is presented in Appendix Four. Generally, if a waste is generated as a result of an activity described in the Federal Register (February 19, 1997), 40 CFR Part 268 - *Land Disposal Restriction: Correction of Tables; Treatment Standards for Hazardous Waste and Universal Treatment Standards; Final Rule*, significant mitigation is likely to be required. Prohibition should be considered if these activities occur within areas which are unsewered or for which alternative sources of drinking water are unavailable.

Mitigation measures may include physical structures and/or modification to facility-specific operational plans and guidelines. The following examples provide a reference by which to measure the degree and nature to which mitigative measures may be employed.

- 1) *Vehicle repair and servicing* located within a designated Critical Aquifer Recharge Area may be allowed if such activities are conducted over impermeable pads and within a covered structure capable of withstanding weather conditions normally expected in the area. No dry wells shall be allowed on site. Dry wells existing on the site prior to facility establishment should be abandoned using techniques approved by the state of Washington Department of Ecology. Chemicals used in the process of vehicle repair and servicing should be stored in a manner that protects them from weather and provides containment should leaks occur. Activities involving auto washing should be conducted per the Best Management Practices presented in Vehicle and Equipment Discharges (WDOE WQ-R-95-56).
- 2) *Residential use of pesticides and nutrients* provides a difficult and unique problem for jurisdictions. Past studies have indicated that improper application has resulted in ground water contamination. In some cases improper use of household pesticides and fertilizers has been shown to be the largest contributor to ground

water degradation (USGS – King County Study). Existing state or federal statutes generally do not regulate application of household pesticides and fertilizers. Adherence to label requirements is the responsibility of the individual property owner as long as the application is not considered commercial application by the state Department of Agriculture. However, the US Department of Agriculture and/or the U.S. EPA have developed application criteria that generally appear on packaging for pesticides, herbicides, and fertilizers. In order to provide the local jurisdiction with a mechanism to deal with extreme cases of over-application, the ordinance should include application of household pesticides, herbicides, and fertilizers at times and rates specified on the packaging, as an exempt activity. However, application of these materials in excess of labeling rates should be subject to local permitting. Inclusion of this caveat would be considered a mitigative measure.

8.0 Exempt Activities

Activities that pose little threat to the ground water, are generally considered those, that have no discharge associated with them or the discharge poses no threat to public health or the environment. These types of activities may include Class V injection wells used only to manage residential or rural non-contact stormwater, on-site sewage systems in working order at densities of one acre or more³, and stormwater management systems that use appropriate best management practices in design and operation. Additionally, provisions of the Growth Management Act require that existing activities classified as legal at the time of adoption of a Critical Aquifer Recharge Area Ordinance be declared exempt. However, if these activities pose a significant threat to ground water quality or quantity, it is recommended that other federal, state, or local statutes or regulations are utilized to address the concern.

8.1 Special Cases – On-Site Sewage Systems

On-site domestic septic systems releasing less than 14,500 gals of effluent per day⁴ have been generally considered an exempt or largely exempt activity. However, recent studies indicate that on-site septic systems can be a significant contributor to ground water contamination, depending upon system density and hydrogeologic conditions. Generally, a maximum density of one system per one acre is sufficient to avoid ground water contamination. However, varying soil types and depths may cause modification to this one system per one acre suggested density. The overall goal of density restrictions is to provide a jurisdiction with a cost effective method to meet both the intent of the ground water quality standards and the Critical Aquifer Recharge Area provisions of the Growth Management Act. It should be noted that density limitations must be coupled with design, construction, and maintenance provisions according to approved local or state requirements if ground water protection is to be accomplished.

³ A density of one system per one acre should be determined based upon soil type, system type, and depth to ground water.

⁴ Systems larger than 14,500 gals per day are regulated by the Washington Department of Ecology

8.2 Special Cases - Spreading or Injection of Reclaimed Water

Reclaimed water is municipal wastewater effluent that has been adequately and reliability treated so that it is suitable for beneficial use. Following treatment it is no longer considered wastewater (treatment levels and water quality requirements are given in the water reclamation and reuse standards adopted by the Washington State Departments of Ecology and Health). In addition, water reuse projects and expected beneficial uses must be identified and described in a water or sewer comprehensive plan, with additional details provided in a facilities plan or engineering report. These projects must include public notice and public involvement at the planning stage. Additionally, monitoring by a responsible utility is highly encouraged.

For surface spreading, the ground water recharge criteria are given in Chapter 90.46.080 RCW and Chapter 90.46.010(10). The requirements for direct injection are given in standards developed by authority of Chapter 90.46.042 RCW. In either case, if the project meets the specified criteria, the Departments of Ecology and Health are obligated to approve the project. However, it is very appropriate to require that any reductions in ground water quality must be disclosed to the public during the planning stage of the project.

8.3 Special Cases – Aquifer Storage and Recovery

In the 2000 legislative session, the Washington Legislature passes SSHB 2867 which added a new section to Chapter 90.44 RCW which authorizes the Department of Ecology to issue reservoir permits to an entity to artificially store and recover ground water in any geological formation which qualifies as a reservoir. The placement of stored water into a geological formation is accomplished through either surface percolation or through direct injection. Generally, the percolation of untreated water from a “pure” surface water source will not degrade the underlying aquifer(s) quality and is therefore of little concern. The injection of surface or other ground water is regulated by the Underground Injection Control Program, as such the quality of the injected water must meet drinking water standards or ground water quality standards (Chapter 173-200 WAC). Given this requirement, there appears to be little risk of ground water quality degradation occurring from the ASR process.

8.4 Special Cases - Existing Activities

Adoption of new rules or Ordinances must consider existing activities and/or facilities. Provided that the existing activity or facility does not pose a significant threat to the public health or environment, it may be allowed to continue over areas designated as a CARA. However, upon modification of the activity (expansion, remodeling, etc.) the jurisdiction is strongly advised to take the opportunity to require the owner/operator to at least meet AKART in order to reduce the potential for contamination of the ground water source(s). Modification need not include an expansion of a facility footprint to trigger compliance with a local CARA ordinance. A rule of thumb should be that if a

modification triggers any local or state permitting or review function, compliance with the ordinance should be required.

9.0 Specific Site Evaluations

CARA ordinances should include provisions whereby a proposed facility, wishing to locate or expand over an area previously designated as susceptible, can conduct a site-specific evaluation to ascertain whether mitigative measures can be put in place that would allow approval of the facility or activity. The specific site evaluation would describe the elements necessary to characterize the site, the activity, and the potential impacts of the project, would contribute to the existing data on which the current CARA boundaries and classifications are based, and may lead to modification in the future. A site-specific evaluation will help determine the level of mitigation and/or monitoring necessary to be applied to a specific activity so that it does not negatively impact ground water quality or recharge. The suggested minimum requirements for a Site Evaluation Report will vary depending upon the results of a potential threat determination and susceptibility classification currently in place.

These evaluation requirements pertain to activities that are not already covered by state regulation which have specific monitoring requirements, such as Chapter 173-303 WAC (Dangerous Waste Regulations), Chapter 173-304 WAC (Minimum Functional Standards for Solid Waste Handling), Chapter 173-351 WAC (Criteria for Municipal Solid Waste Landfills), and Chapter 402-52 WAC (Uranium and/or Thorium Mill Operation and Stabilization of Mill Tailing Piles) [WAC 173-200-080(6)].

When considering the issuance of a “permit to locate over a designated CARA” the following information should be compiled by the owner or operator of the project and evaluated by the local jurisdiction:

- Current environmental conditions.
- Constituents released into the environment by the activity.
- The potential to degrade the environment by the activity.

The level of detail required to address these issues will depend on several factors such as:

- The applicants desire to challenge a current CARA designation.
- The current designation of the CARA or portion of the CARA.
- The extent to which the applicant is willing to impose mitigative measures.

The goal of the Site Evaluation is to assess the current condition of the hydrogeologic environment and to characterize the facility's activity. This information is used to establish mitigation measures within a land use or Critical Aquifer Recharge Area permit and/or to determine whether sufficient threat exists to allow permitting of the activity. In some cases

the local jurisdiction may wish to use the results of the Site Evaluation Report as the basis for requiring the development of a monitoring plan which will accurately assess each individual facility's impact on ground water quality.

9.1 Characterization Requirements

The scope of work for the Site Evaluation Report should be evaluated and approved by the local jurisdiction. Some of these required elements described in Section 9.0 are also required by Chapter 173-200 WAC to achieve compliance with the Ground Water Quality Standards. Generally, there will be two levels of Site Evaluation Reports. The extent to which a site should be characterized will depend upon a classification of potential threat. The extent of the study should be based upon the nature of the activity, the type and quantity of chemicals used on site, the constituents discharged in the wastewater, and the geographic characteristics of the area.

The level of effort required to complete each element is dependent upon the facility and its unique situation. For facilities that have a limited potential to contaminate ground water, the Site Evaluation Report may be waived. For facilities that are not anticipated to have a substantial impact on the environment, a less intensive hydrogeologic study may be appropriate. If the information is available, this could be completed through a literature search and discussion of the site and the proposed activities. The level of expectation should be discussed with the local jurisdiction.

The following section details the information that should be compiled for the Site Evaluation Report and additional requirements that may be necessary depending upon the activity and the complexity of the site. These elements should be addressed in the scope of work for the Site Evaluation Report.

Class A Site Evaluation Report Requirements:

Class A Site Evaluation Reports should be considered in order to evaluate areas within the boundaries of the CARA that have initially been rated as moderately susceptible. Areas that have been rated as having a low susceptibility generally will not require further site evaluation.

Class A Site Evaluation Reports are designed to provide basic information about the hydrogeologic characteristics of the site. The information required in a Class A Site Evaluation should be readily available from existing sources (federal, state, or local agencies). In-field investigations should be kept to a minimum.

Contents of a Class A Site Evaluation Report should be:

- Permeability of the unsaturated zone.
- Location of nearby sensitive areas (wellhead protection areas, special protection areas, etc.).
- Ground water depth and flow direction.

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- Location, construction, and use of existing wells (1/4 mi.).
- Site map at 1:2,400 (1 inch to 2,000 feet) scale.
- Activity characterization.
- Best Management Practices.
- Contingency Plan.

Class B Site Evaluation Report Requirements:

Class B Site Evaluation Reports should be considered in order to evaluate areas within the boundaries of the CARA that have initially been rated as susceptible⁵. Areas that have been rated as having a low susceptibility generally will not require further site evaluation.

Class B Site Evaluation Reports are designed to provide detailed information about the hydrogeologic characteristics of the site and to predict the behavior of a contaminant should it reach the underlying aquifer(s). The information required in a Class B Site Evaluation should be newly acquired information that will allow the jurisdiction to make an informed decision regarding the risks of allowing otherwise prohibited activities to go forth.

These evaluation reports should contain all the information included as part of a Class A Site Evaluation Report along with the following additions:

- Background water quality compiled over at least a one year period.
- Contaminant transport modeling based on potential releases to ground water.
- Modeling of ground water withdrawal effects.
- Geologic and hydrogeologic characteristics.
- Ground water monitoring plan provisions.

9.2 Description of Requirements

Geology and Hydrogeology

The geology of a site should be characterized through the interpretation of well logs, geologic maps, and cross sections. Cross sections can be constructed from information contained in drillers' logs and geological reports. This information may be required if the geology is complex or if there are multiple aquifer systems. Structural features should be

⁵ In rare cases the jurisdiction may wish to consider allowing siting of an activity over a highly susceptible area when a legitimate case can be made that in doing so the greater public interest would be served.

delineated, such as faults, fractures, fissures, impermeable boundaries or other subsurface features that might provide preferential pathways for contaminant migration.

The geomorphology of the area should be described including the topography and drainage patterns. The soils on the site should be identified and described by type, horizontal and vertical extent, infiltration rate, organic carbon content, and mineral content.

The lithology of the uppermost aquifer and the overlying units in the unsaturated zone should be defined in terms of thickness, permeability, and aerobic or anaerobic conditions. These parameters will be used to identify contaminant movement and behavior prior to reaching ground water.

Additional hydrogeologic parameters should be identified, such as ground water velocity, transmissivity, storage coefficient, hydraulic conductivity, porosity, and dispersivity. These hydrogeologic parameters may be necessary to characterize the rate of contaminant movement in the aquifer and to accurately assess the area potentially impacted by the facility's activities. Ground water flow conditions such as the flow rates, volumes, and directions should be identified. Any available hydrographs or equipotential maps should also be included.

Precipitation, evaporation, and evapotranspiration rates should be identified for the area. Contaminant fate and transport, including probable migration pathways, should also be included.

Location of Sensitive Areas

The location of previously defined sensitive areas should be included as part of both a Class A and Class B site evaluation. The purpose of including these areas is to make both the jurisdiction and the applicant aware of areas requiring protection beyond that which may be afforded in the CARA. Generally, sensitive areas extending outward in a three-mile radius from the proposed activity should be considered as adequate.

Ground Water Depth and Flow Direction

The position of the water table and the direction of ground water movement can be determined by mapping the static water level recorded from area wells. This is necessary to establish the directions that contaminants will migrate once released into the environment.

Depth to ground water below the land surface should also be defined by taking static water levels from a reasonable number of wells for a period of time sufficient to characterize ground water elevation trends. Water level elevations should be monitored on a monthly or quarterly basis to determine seasonal variations in ground water flow. Seasonal water level fluctuations in the uppermost aquifer may occur and should be taken into account when developing permit conditions. Seasonal water table elevation can sometimes be detected in the soil horizon by identification of mottled soil.

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A ground water potentiometric map illustrating ground water flow directions should be included for *all aquifers* that have a potential to be contaminated by the discharge. Data allowing for the determination of flow direction and ground water gradient should include the locations of wells, dates of measurements, locations of measuring points relative to the land surface elevation, depth to water, time since the wells were last pumped, other area wells which were pumping during the measurement, and any available construction data such as total depth and screened interval. A contour map should be drawn from the resulting information. Ground water divides should also be noted.

Discharges to the subsurface can cause a mounding effect of ground water. Mounding can influence the local hydraulic gradients that may impact the effectiveness of the monitor wells. The potential of a discharge to alter the gradient due to ground water mounding should be evaluated prior to developing a monitoring plan.

Background Water Quality

Background water quality is defined as the quality of ground water that is representative of the conditions without the impacts of the proposed activity or facility. Because individual ground water samples are only representative of ground water quality at a specific time and location they (by themselves) cannot provide an adequate assessment of water quality over a period of time. To satisfy the requirement for a background water quality determination, at least eight samples collected over a one-year period with no more than one sample collected during any month in a single calendar year, upgradient from the activity or facility must be obtained. Background water quality can then be determined using methodologies outlined in Ecology publication # 96-02, *Implementation Guidance for the Ground Water Quality Standards*.

Location and Construction of Existing Area Wells

All wells within a one-quarter mile radius of the discharge point should be located on a 1:24,000 scale map. This includes domestic, irrigation, monitor, and public drinking water supply wells. The level of detail will depend on the complexity of the wastewater and the hydrogeology of the site. Available information on the well use and construction should be included for all contiguous wells and other representative wells within the 1/4-mile radius. Construction information should consist of well depth, static water level, screened interval, and geologic well logs. This information will be used for determining geologic characteristics of the subsurface, developing potentiometric maps, assessing the adequacy of wells for sample collection, and evaluating potential impacts to area wells in the event of environmental contamination.

Details of any proposed monitor wells should be submitted to Ecology to assure they are located and designed properly prior to installation. Guidelines for monitor well design are discussed in this chapter in Section 5.4.

Activity Characterization

Activities within a CARA may be classified according to two categories: 1) those which have little or no potential to impact ground water quality or recharge and; 2) those which do have a potential. Those activities classified as “Exempt” under Section VII should be considered as possessing a low threat to ground water. All other activities must be considered a potential threat to ground water.

Contingency Plans

The Site Evaluation Report should include a spill plan or a contingency plan depending upon the individual circumstances. A contingency plan should be prepared which describes the specific actions to be taken if a violation occurs. A contingency plan should identify all the equipment and structural features that could potentially fail, resulting in immediate public health or environmental impacts. A plan should be developed that describes the action(s) necessary to remedy impacts of such an event in a timely manner. This includes an outline of the procedures for controlling the release, the proposed methods for evaluating the extent of contamination, and alternatives for remediation. An emergency response coordinator should also be identified. This person is responsible for notifying proper authorities and implementing the contingency plan in the event of a release to the environment that may cause imminent or substantial endangerment to public health or the environment.

Contaminant Modeling

The area potentially affected by pollutant migration should be described. This is the area that will be affected chemically, physically or biologically as a result of the activity. The area impacted should take into account advection, dispersion, and diffusion of contaminants in ground water. The size of the area will depend upon the effluent quality, the aquifer characteristics, and the rate of assimilation. The applicant can demonstrate this by using a simple mixing equation or a computer model.

The location of the facility should be illustrated on a 1:2400 scale map, plus an enlarged map of the facility. The facility site boundary and land ownership or uses of the adjacent property should also be delineated on this map. Additionally, a site plan should be submitted that is drawn to approximate scale. The site map should include the following; property lines, buildings, structures, locations of wells, locations of other underground conveyance systems (i.e., underground storage tanks, septic systems, water lines, gas lines, etc.), location of geologic borings, the discharge point location, topography, plus any other relevant information.

Previous land use should be identified to determine what, if any, contaminants may be present in the subsurface. Consideration should be given to those discharges that have a potential to mobilize pollutants already present in the environment. Even though a discharger may not be responsible for contributing these pollutants to the environment, they are responsible for mobilizing or increasing the contaminant plume.

Two examples of this situation are described below:

1. A previous facility discharged metals that were attenuated in the vadose zone but were never detected in ground water. Years later a new facility moved into the area and discharged water with a low pH. Although the facility is not discharging metals, elevated concentrations were detected in ground water as a result of the new facility's activities.
2. Another example involves a leaking underground storage tank (LUST) that released petroleum products to the subsurface, but is involved in remediation. A new facility located hydraulically upgradient, discharged large quantities of "clean water". As a result of this discharge, the water table is raised causing a mounding effect and as a consequence, the plume from the LUST site is mobilized and the contaminant plume size increased.

In both of these situations ground water has been degraded as a result of the discharge.

9.3 Additional Characterization Considerations

As regulatory and land use decisions continue to be based more and more on “watershed” considerations, it will become increasingly necessary to understand the inter-relationship between the ground and surface water resource(s).

Regulatory activities such as the development and implementation of Total Daily Maximum Loads (under the federal Clean Water Act) or Endangered Species designations require a more comprehensive understanding of the entire hydrologic system. Land use decisions made years ago simply based on impact to ground water without

consideration of the further impact that ground water may have of a surface water body at the point of discharge, may contribute to degradation of that surface water body. Likewise, decisions made based solely on a potential impact to surface water quality may have severe ramifications to ground water quality. It is highly recommended that future characterizations consider the ground water – surface water connectivity.

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Appendix One

Suggested Definitions for Use in Local Ordinances

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- (1) "Aquifer" means a geological formation, group of formations or part of formation this is capable of yielding a significant amount of water to a well or spring.
- (2) "Class I Injection Well" means a well used to inject industrial, commercial, or municipal waste fluids beneath the lowermost formation containing, within 1/4 mile of the well bore, and underground source of drinking water.
- (3) "Class II Injection Well" means a well used to inject fluids:
 - (a) Brought to the surface in connection with conventional oil or natural gas exploration or production and may be commingled with wastewater's from gas plants that are an integral part of production operations, unless those waters are classified as dangerous wastes at the time of injection.
 - (b) For enhanced recovery of oil or natural gas; or
 - (c) For storage of hydrocarbons that are liquid at standard temperature and pressure.
- (4) "Class III Injection Well" means a well used for extraction of minerals, including but not limited to the injection of fluids for:
 - (a) In-situ production of uranium or other metals that have not been conventionally mined;
 - (b) Mining of sulfur by Frasch process; or
 - (c) Solution mining of salts or potash.
- (5) "Class IV Injection Wells" means a well used to inject dangerous or radioactive waste fluids.
- (6) "Class V Injection Wells" means all injection wells not included in Classes I, II, III, or IV.
- (7) "Confined aquifer" means an aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself and that contains ground water under sufficient pressure for the water to rise above the top of the aquifer.
- (8) "Confining Formation" means the relatively impermeable formation immediately overlying an artesian aquifer.
- (9) "Critical Aquifer Recharge Area" means areas that are determined to have a critical recharging effect on aquifers used as a source for potable water, and are vulnerable to contamination from recharge.
- (10) "Formation" means an assemblage of earth materials grouped together into a unit that is convenient for description or mapping.

- (11) "Ground water" means water in a saturated zone or stratum beneath the surface of land or water.
- (12) "Ground Water Management Area" means a specific geographic area or subarea designated pursuant to Chapter 173-100 WAC for which a ground water management program is required.
- (13) "Ground water management program" means a comprehensive program designed to protect ground water quality, to assure ground water quantity, and to provide for efficient management of water resources while recognizing existing ground water rights and meeting future needs consistent with local and state objectives, policies and authorities within a designated ground water management area or subarea and developed pursuant to Chapter 173-100 WAC.
- (14) "Hazardous substances" means any liquid, solid, gas, or sludge, including any material, substance, product, commodity, or waste, regardless of quantity, that exhibits any of the physical, chemical or biological properties described in Chapter 173-303-090 or 173-303-100 WAC.
- (15) "Hydrologic soil groups" means soils grouped according to their runoff-producing characteristics under similar storm and cover conditions. Properties that influence runoff potential are depth to seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a low permeable layer. Hydrologic soil groups are normally used in equations that estimate runoff from rainfall, but can be used to estimate a rate of water transmission in soil. There are four hydrologic soil groups: A, with low runoff potential and a high rate of water transmission; B with moderate infiltration potential and rate of water transmission; C, with a slow infiltration potential and rate of water transmission; and D, with a high runoff potential and very slow infiltration and water transmission rates.
- (16) "Infiltration" means the downward entry of water into the immediate surface of soil.
- (17) "Perched ground water" means ground water in a saturated zone is separated from the main body of ground water by unsaturated rock.
- (18) "Permeability" means the capacity of an aquifer or confining bed to transmit water. It is a property of the aquifer and is independent of the force causing movement.
- (20) "Potable water" means water that is safe and palatable for human use.
- (21) *"Qualified ground water scientist" means a hydrogeologist, geologist, engineer, or other scientist who meets all the following criteria:*

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- a. Has received a baccalaureate or post-graduate degree in the natural sciences or engineering; and
 - b. Has sufficient training and experience in ground water hydrology and related fields as may be demonstrated by state registration, profession certifications, or completion of accredited university programs that enable that individual to make sound professional judgments regarding ground water vulnerability.
- (22) "Recharge" means the process involved in the absorption and addition of water to ground water.
 - (23) "Soil Survey" means the most recent National Cooperative Soil Survey for the local area or county by the Soil Conservation Service, United States Department of Agriculture.
 - (24) "Sole Source Aquifer" means an area designated by the U.S. Environmental Protection Agency under the Safe Drinking Water Act of 1974, Section 1424(e). The aquifer(s) must supply 50% or more of the drinking water for an area without a sufficient replacement available.
 - (26) "Aquifer Susceptibility" means the ease with which contaminants can move from the land surface to the aquifer based solely on the types of surface and subsurface materials in the area. Susceptibility usually defines the rate at which a contaminant will reach an aquifer unimpeded by chemical interactions with the vadose zone media.
 - (27) "Unconfined aquifer" means an aquifer not bounded above by a bed of distinctly lower permeability than that of the aquifer itself and containing ground water under pressure approximately equal to that of the atmosphere. This term is synonymous with the term "water table aquifer".
 - (28) "Vulnerability" is the combined effect of susceptibility to contamination and the presence of potential contaminants.
 - (29) "Wellhead Protection Area" means the surface and subsurface area surrounding a well or well field that supplies a public water systems through which contaminants are likely to pass and eventually reach the water well(s) as designated under the Federal Clean Water Act.
 - (30) "Water table" means that surface in an unconfined aquifer at which the pressure is atmospheric. It is defined by the levels at which water stands in wells that penetrate the aquifer just far enough to hold standing water.
 - (31) "Well" means a bored, drilled or driven shaft, or a dug hole whose depth is greater than the largest surface dimension.

Appendix Two

Example Critical Aquifer Recharge Area Classification Based On Susceptibility Ratings

Ratings of susceptibility for aquifers is an acceptable method of determining what may be a Critical Aquifer Recharge Area. Using the basic parameters presented in Section 5.1 of this guidance, the following scheme has been designed to rate the susceptibility of aquifers. This rating system is presented as an example that may be used to determine the boundaries of a CARA depending on the adequacy of previous characterizations conducted within a jurisdiction.

Each of the major parameters used to estimate susceptibility has been evaluated and rated. These rating tables and examples of their use are presented below.

Table One: Soil Permeability Designations Based On Soil Survey (SCS)

Condensed Description	Soil Survey Description	Permeability (in / hr)	Permeability (cm / sec)	Rating
Very Slow	Very Slow	< 0.06	<.00453	0
Slow	Slow	0.06 - .20	.00453 - .0141	1
	Moderately Slow	0.20 - 0.60	.0141 - .0423	
Moderate	Moderate	0.60 - 2.0	.0423 - .1411	2
	Moderately Rapid	2.0 - 6.0	.1411 - .4233	
Rapid	Rapid	6.0 - 20	.4233 - 1.411	3
	Very Rapid	> 20	> 1.411	

Table Two: Geologic Matrix Designations

(from Fetter, 1980 - Freeze and Cherry, 1979)

Condensed Description	Geologic Matrix	Permeability (cm / sec)	Rating
Very Slow	Unfractured Igneous or Metamorphic Bedrock, Shale	$10^{-9} - 10^{-13}$	0
	Marine Clay, Clay, Dense Sandstone, Hardpan	$10^{-7} - 10^{-9}$	
Slow	Loess, Glacial Till, Fractured Igneous or Metamorphic Bedrock	$10^{-5} - 10^{-8}$	1
	Silt, Clayey Sands, Weathered Basalt	$10^{-3} - 10^{-7}$	
Moderate	Silty Sands, Fine Sands, Permeable Basalt	$10^{-1} - 10^{-4}$	2
	Clean Sands, Karst Limestone	$10^0 - 10^{-1}$	
Rapid	Sand and Gravel	$10^1 - 10^0$	3
	Gravel	$10^2 - 10^{-1}$	

Table Three: Infiltration (Precipitation - PET)

Condensed Description	Infiltration (inches)	Rating
Very Low	0 - 1	0
Low	1 - 3	1
Moderate	3 - 9	2
High	> 9	3

Table Four: Depth to Water

Condensed Description	Depth to Water (Feet)	Rating
Very Low	Confined Aquifer	0
	> 50	
Low	25 - 50	1
Moderate	10 - 25	2

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High	0 - 10	3
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The following four situations are presented as examples on the use of a susceptibility rating system. The various scores assigned to the four parameters are found in Tables 1 through 4 within this appendix. Conditions for each table's use are specified in Section 5.1 of this guidance document. To determine an overall susceptibility the following scale is recommended:

Low Susceptibility	Moderate Susceptibility	High Susceptibility
0 - 3	4 - 7	8 - 12

Example One

The soils overlying an area near Longview, WA vary in thickness from 5 to 10 feet. These soils range in permeability from .60 - 2.0 in/hr as determined in the county soil survey. Three well logs, (obtained from the Southwest Regional Office of the Department of Ecology) indicate that silty clays exist from 10 to 30 feet below land surface. Fine sands that appear to be saturated are present from 25 to 30 feet. A layer of clay is present from 30 to 36 feet below the surface. A layer of saturated sand and gravels exist from 37 to 50 feet. The wells are screened into the bottom sand and gravel layer with 10-foot well screens. Using the tables in Appendix Three an overall infiltration of 19.1 inches (Precip – PET) is estimated. Based on the geology of the area and the fact that a clay layer overlies the water-bearing zone, it is determined that the aquifer is confined.

Rating: Soils	Permeability	2
	Geologic Matrix	0
	Infiltration	3
	Depth to water	2
	Total	7

This rating indicates that the area should be considered as moderately susceptible. This rating is based largely on the presence of a saturated zone above the aquifer used as a water source. Compromising the clay layer via poor drilling techniques raises the rating from a potential of 5 to 7.

Example Two

The soils overlying an area near Prosser, WA vary in thickness from 2 to 12 feet. These soils range in permeability from 2.0 - 6.0 in/hr as determined in the county soil survey. Four well logs (obtained from the Central Regional Office of the Department of Ecology) indicate that from 12 to 43 feet below land surface exists fine sands and glacial till. Silty sands appear from 43 to 57 feet below the surface. Saturated sand and gravels, into which the wells are screened, exist from 57 to 68 feet below land surface. Using the tables in Appendix Three an overall infiltration of 19.1 inches (Precip – PET) is estimated. Depth to water has been measured from 59 to 65 feet.

Rating:	Soils Permeability	2
	Geologic Matrix	1
	Infiltration	0

Depth to water	0
Total	3

This rating indicates that the area should be considered as a low susceptibility. *If the area in question receives irrigation in addition to normal precipitation, the irrigation must be added to the precipitation amount as a total.*

Example Three

The soils overlying an area near Forks, WA vary in thickness from 6 to 10 feet. These soils range in permeability from 2.0 - 6.0 in/hr as determined in the county soil survey. Four well logs (obtained from the regional office of the Department of Ecology) indicate that from 10 to 14 feet below land surface exists a layer of till. Saturated sands and gravels exist from 14 to 23 feet below land surface. Using the tables in Appendix Three an overall infiltration of 93.9 inches (Precip – PET) is estimated. Depth to water has been measured at 15 feet.

Rating: Soils	Permeability	2
	Geologic Matrix	3
	Infiltration	3
	Depth to water	2
	Total	10

This rating indicates that the area should be considered as one of high susceptibility.

Appendix Three

Tables for the Determination of Infiltration Rates

Station	Precip.	PET
Adams County		
Hatton	9.8	25.8
Lind Exp. Station	10.3	27.2
Othello	8.8	26.7
Ritzville	11.5	25.6
Ruff	10.1	26.4
Asotin County		
Anatone	21.1	22.3

Clarkston Heights	13.1	26.9
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Benton County

Kennewick	7.5	29.1
Prosser	7.7	26.8

Chelan County

Chelan	11.2	26.8
Leavenworth	23.2	25.3
Stehekin	33.8	23.9
Wenatchee	8.8	27.2

Clallam County

Callam Bay	83.3	23.7
Forks	118.0	24.1
Port Angeles	24.5	24.1
Sequim	17.1	24.3
Tatoosh Island	75.6	23.9

Clark County

Vancouver	39.1	27.4
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Columbia County

Dayton	19.6	26.0
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Cowlitz County

Longview	45.1	26.0
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Douglas County

Waterville	11.6	23.4
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Ferry County

Laurier	19.1	25.0
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Station

Precip.

PET

Ferry County (cont.)

Nespelem	13.3	24.9
Republic	15.1	22.2

Franklin County

Hatton	9.8	25.8
Othello	8.8	26.7

Garfield County

Pomeroy	16.8	25.5
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Pullman Research Station	19.4	24.6
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Grant County

Ephrata	8.4	29.4
Hartline	11.0	26.3
Ruff	10.1	26.4

Grays Harbor County

Aberdeen	84.8	25.0
Oakville	55.2	17.8
Quinault	132.7	26.0

Island County

Coupsville	17.6	24.3
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Jefferson County

Quilcene	50.0	25.1
Port Townsend	18.3	25.2

King County

Bothell	39.5	24.7
Cedar Lake	104.4	23.2
Palmer	93.4	24.7
Seattle-Tacoma Airport	33.8	25.3
Seattle	34.8	26.6
Snoqualmie Falls	60.3	25.4
Stampede Pass	93.6	17.7
Vashon	46.5	25.8

Kitsap County

Bremerton	38.7	25.9
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Station

Precip.

PET

Kittitas County

Ellensburg Airport	8.5	25.0
Lake CleElum	36.2	22.5
Lake Kachess	54.9	21.8

Klickitat County

Bickleton	12.0	24.3
Goldendale	17.6	24.3
Mt. Adams Ranger Station	49.4	23.0

Lewis County

Centralia	45.4	26.0
Kosmos	60.1	24.3
Lincoln County		
Davenport	16.7	23.6
Odessa	10.6	25.5
Sprague	14.7	25.2
Wilbur	12.8	23.9
Mason County		
Cushman Dam	100.3	25.7
Grapeview	53.1	26.3
Shelton	64.0	25.6
Okanogan County		
Conconully	14.9	23.3
Nespelem	13.3	24.9
Omak	11.3	25.7
Oroville	11.6	27.0
Winthrop	14.5	23.7
Pacific County		
Willapa Harbor	86.0	25.3
Pend Oreille County		
Metaline Falls	27.6	23.2
Newport	26.7	22.6
Pierce County		
Buckley	48.8	25.0
Longmire Ranger Station	81.4	22.1
Station	Precip.	PET
Pierce County (cont.)		
Puyallup	40.3	25.6
Tacoma	35.2	27.3
San Juan County		
Olga	28.8	24.8
Skagit County		
Anacortes	25.7	25.8
Concrete	64.6	26.5
Sedro Woolley	45.2	25.6

Critical Aquifer Recharge Area Ordinance Development Guidance

Skamania County

Wind River	99.8	23.6
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Snohomish County

Darrington	80.4	24.7
Everett	34.7	25.4
Monroe	46.0	25.7
Startup	63.3	25.6

Spokane County

Deer Park	21.9	23.0
Spokane	14.9	24.4

Stevens County

Chewelah	19.5	23.7
Colville	17.5	24.4
Northport	19.2	25.6

Thurston County

Olympia	45.9	24.9
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Walla Walla County

Walla Walla	14.1	28.4
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Whatcom County

Bellingham	33.6	24.6
Blaine	41.7	24.9
Marietta	31.8	25.0
Newhalem	77.7	26.0

Station

Precip.

PET

Whitman County

Colfax	21.2	24.9
LaCrosse	14.2	25.5
Pullman	19.4	24.6
Rosalia	18.3	24.5

Precipitation = Precip.

Potential Evapotranspiration = PET

Appendix Four

Department of Ecology

Existing Guidance Documents

Department of Ecology Guidance Documents

Document Number	Publication Title
75-011 *	A Guide for Perspective Well Owners
86-002 *	Guidelines for the Development of Ground Water
87-003 *	Ground Water Resource Protection: A Handbook for Local Planners and Decision Makers
91-012c	Dry Cleaning Hazardous Waste Do's and Don'ts
91-0129	Electroplating
91-030	Guidance for Remediation of Petroleum Contaminated Soils
91-042	Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients
92-br-008	Empty Pesticide Container Disposal
92-br-009	Managing Hazardous Waste for Radiator Shops
93-br-010	Managing Hazardous Waste for Transmission Shops
93-br-013	Managing Hazardous Waste for Service Stations
93-br-015	Managing Hazardous Waste for Tire Dealers
93-009	Surface and Ground Water on Coastal Bluffs: A Manual of

93-012	Practices for Coastal Property Owners Tank Owners and Operators Guide to Using Ground Water Monitoring for UST Release Detection
94-139	A Guide for Lithographic Printers
94-138	A Guide for Photo Processors
94-137	A Guide for Screen Printers
94-146	Best Management Practices to Prevent Stormwater Pollution at Vehicle Recycling Facilities
95-053	Prevention of Stormwater Pollution at Log Yards - Best Management Practices
95-056	Vehicle and Equipment Washwater Discharges - Best Management Practices
95-405A	Best Management Practices for Automobile Dealerships- Auto Wastes and Containers
95-405B	Best Management Practices for Auto Dealerships - Waste Processes
96-013	Irrigation Best Management Practices to Protect Ground Water and Surface Water Quality
96-422	Frequently Asked Questions Concerning Solvent and Cleaner Disposal
96-1254	Management Requirements for Special Waste
F-HWTR-93-541	Drycleaners
WQ-R-93-011	Selecting Best Management Practices for Stormwater Management

- **Limited copies exist and may not be available for distribution. Contact WDOE publications office**

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Phillips, Earl L., 1966. *Washington Climate for these Counties, Clallam Grays Harbor, Jefferson, Island, Pacific, San Juan, Skagit, Snohomish, Watcom*. Washington State University

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